



# **SAS: Today's Fast and Flexible Storage Fabric**

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# Abstract

- SAS is the backbone of nearly every enterprise storage deployment, rapidly evolving, adding new features and enhanced capabilities, and offering “no compromise” system performance. SAS not only excels as a device level interface, its versatility, reliability and scalability have made it the connectivity standard of choice for creating new enterprise storage architectures.
- This presentation covers the advantages of using SAS as a device interface and how its capabilities as a connectivity solution are changing the way data centers are being deployed. 12Gb/s SAS transfer rates, bandwidth aggregation, SAS fabrics (including switches) active connections, and multi-function connectors allow data center architects to create sustainable storage solutions that scale well into next-generation 24Gb/s SAS designs and beyond.

# Today's Takeaways

## ➤ Flexibility of SAS is Unparalleled

- ◆ Media flexibility
- ◆ Scalability
- ◆ System architectures

## ➤ SAS Technology Addresses a Very Large, Growing Market

## ➤ SAS Continues to Evolve through Innovation

- ◆ Performance
- ◆ Features



# SAS – Preserving the Past, Creating the Future

## Preserve Legacy SCSI

- 25 years of SCSI middleware



## Customer Choice

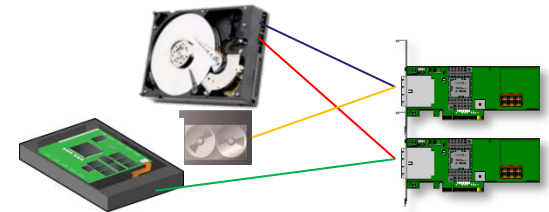


- 3.5" and 2.5" form factors
- Plug compatible
- Multi-protocol



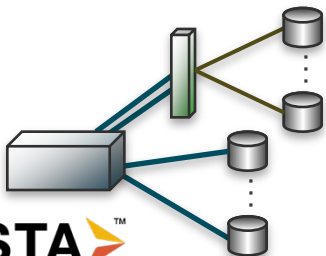
## Usability

- Dual-ported
- Point-to-point
- Cost equal to SCSI



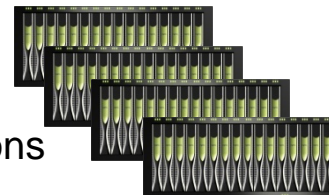
## Future Architected

- Protocol extends to new technologies
- Serial, switchable
- SFF connectors



## Scalable

- 1000s of connections



## Performance

- Wide ports
  - Interconnect
  - MultiLink SAS<sup>™</sup>
- Low overhead

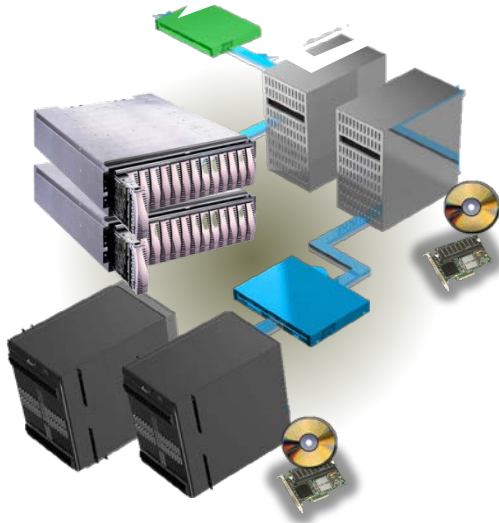


SAS: Today's Fast and Flexible Storage Fabric

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# SAS & SATA Span the Storage Spectrum

## Direct Attach Storage



- Controllers/ROCs/HBAs
- Expanders
- SAS/SATA HDDs
- SAS/SATA SSDs

## SAS Fabrics



- Expanders
- SAS switches
- Bridges
- Port multiplexers

## External Storage



- Controllers/ROCs/HBAs
- Expanders
- SAS/SATA HDDs
- SAS/SATA SSDs
- SAS/SATA tape

## Media



- SAS HDDs
- SAS SSDs
- SATA HDDs
- SATA SSDs
- Near-line SAS HDDs
- SMR HDDs

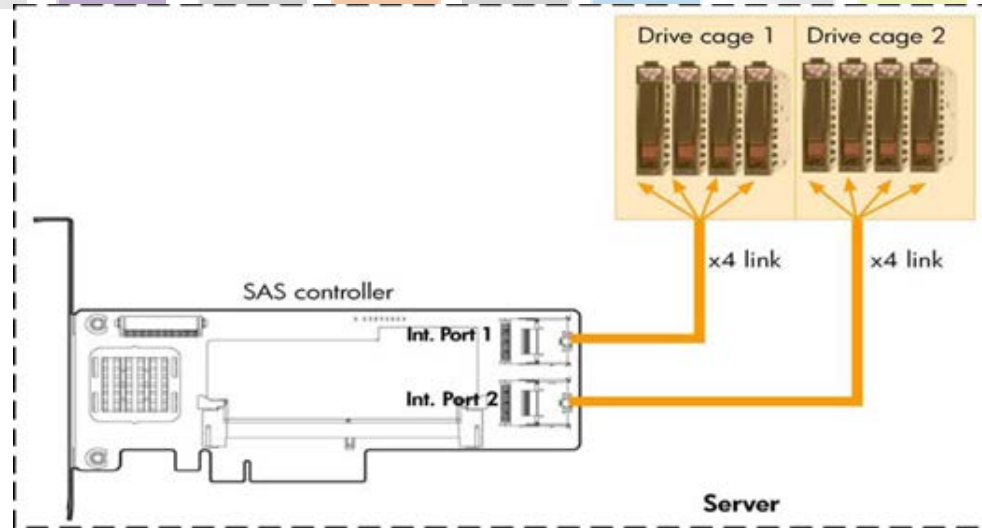
***SAS is the Predominant Enterprise Drive Interface***



# Scalability in Server & Hyper-Converged Architectures

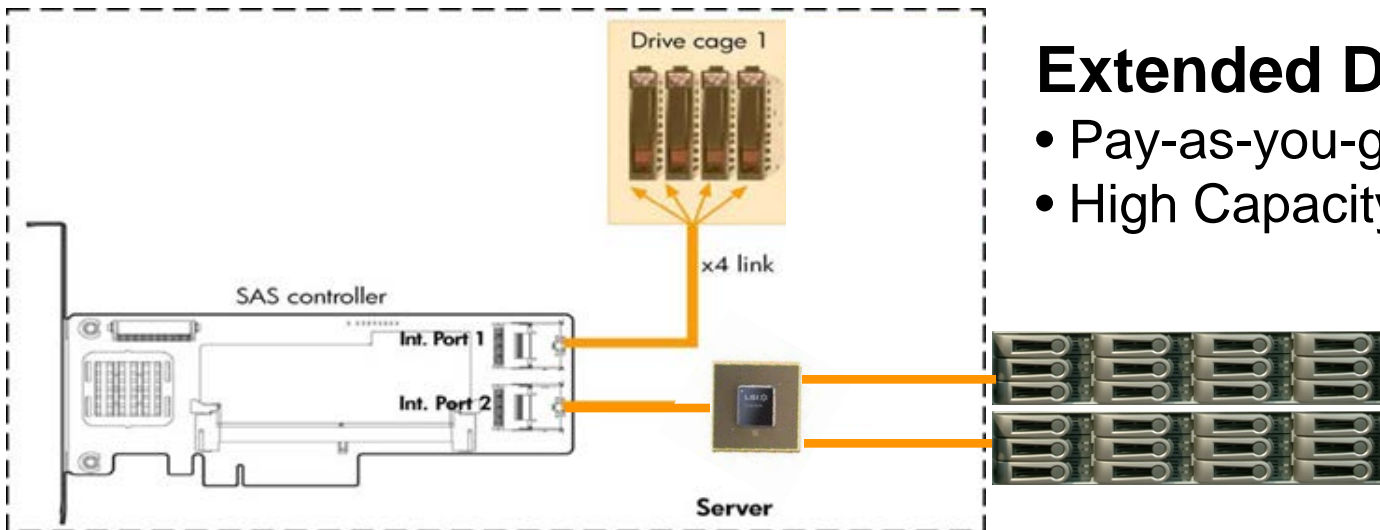
## Simple DAS

- High Performance
- Inexpensive
- Modular

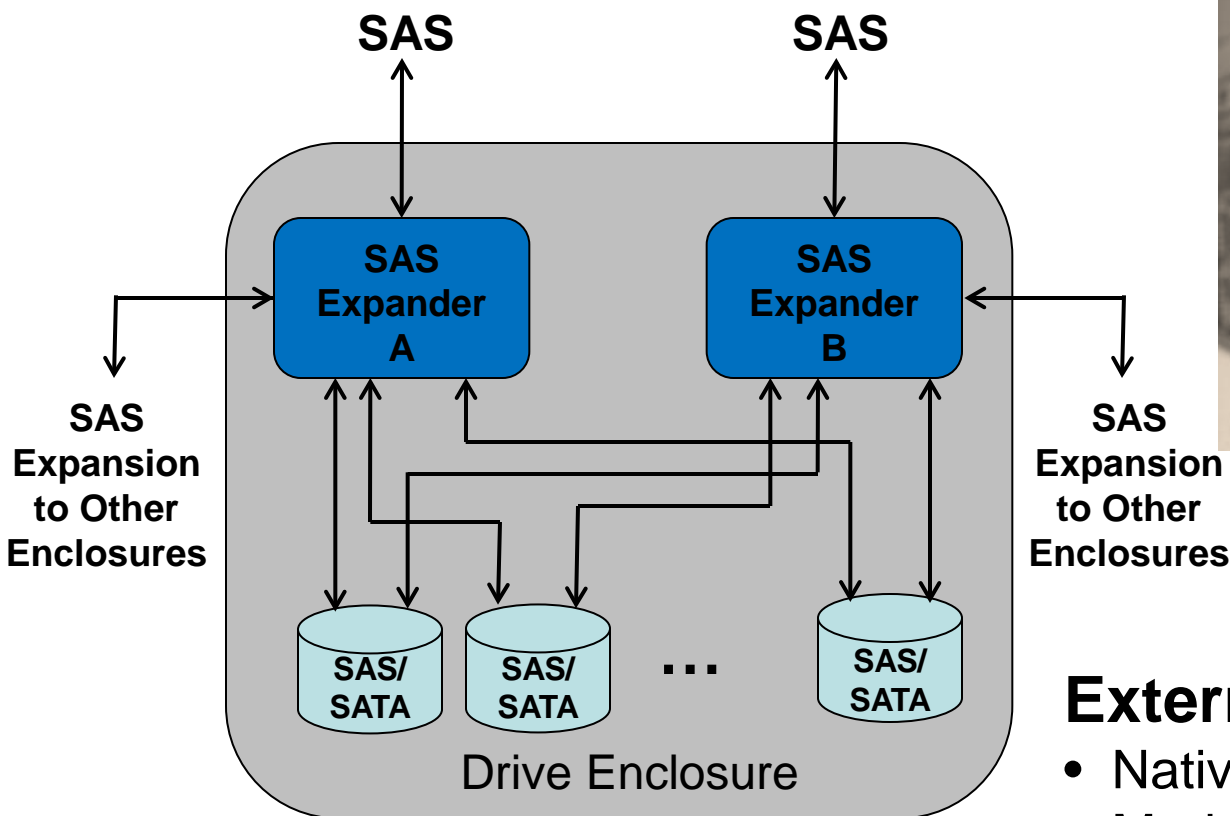


## Extended DAS

- Pay-as-you-grow
- High Capacity



# Scalability in External Storage Architectures



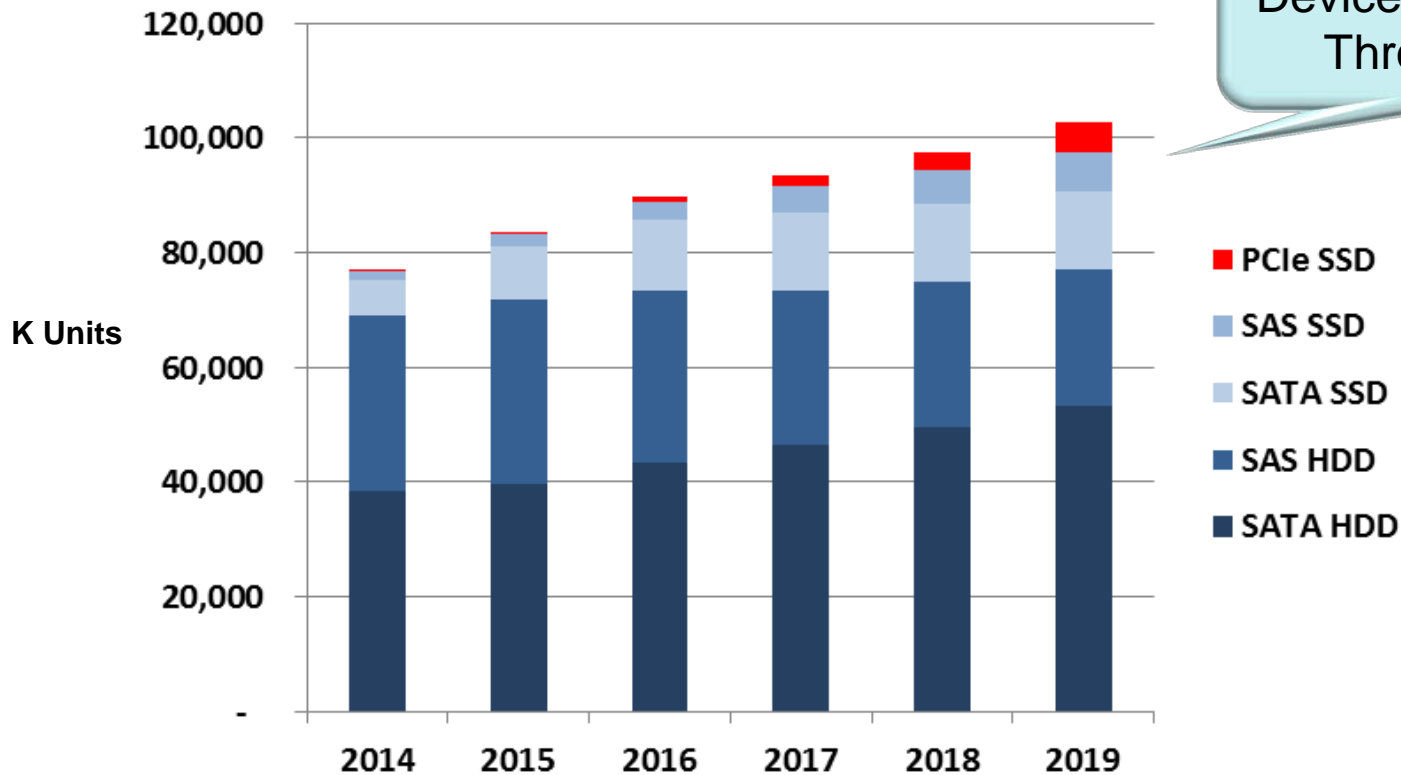
## External Storage:

- Native High-Availability
- Modular
- Simplified, Robust Cabling
- Scales to 1000s of Devices



# Enterprise Unit Shipments

SAS Attached  
Devices Grow at 5%  
Through 2019



**95% of All Enterprise Shipments in 2019  
Require SAS Infrastructure**

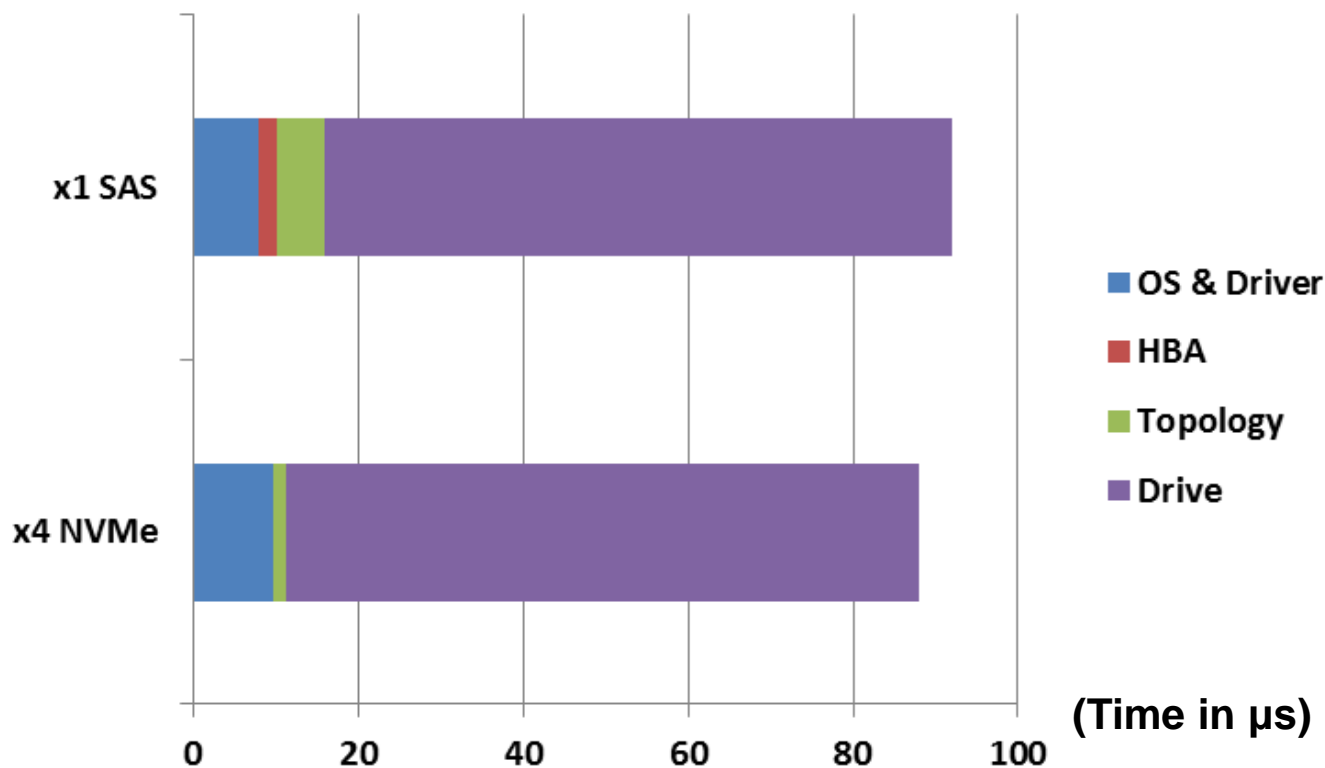
# Bandwidth by the Numbers

|  | <b>SATA</b>                  | <b>x1 PCIe</b>               | <b>x1 SAS</b>                 | <b>x2 PCIe</b>               | <b>x2 SAS<br/>MultiLink<br/>SAS™</b> | <b>x4 PCIe</b>               | <b>x4 SAS<br/>MultiLink<br/>SAS™</b> |
|--|------------------------------|------------------------------|-------------------------------|------------------------------|--------------------------------------|------------------------------|--------------------------------------|
| <b>No. of Links /<br/>Lanes</b>        | <b>1</b>                     | <b>1</b>                     | <b>1</b>                      | <b>2</b>                     | <b>2</b>                             | <b>4</b>                     | <b>4</b>                             |
| <b>Transfer Rate<br/>per Link/Lane</b> | Half-duplex<br><b>6 Gb/s</b> | Full-duplex<br><b>8 Gb/s</b> | Full-duplex<br><b>12 Gb/s</b> | Full-duplex<br><b>8 Gb/s</b> | Full-duplex<br><b>12 Gb/s</b>        | Full-duplex<br><b>8 Gb/s</b> | Full-duplex<br><b>12 Gb/s</b>        |
| <b>Max Bandwidth</b>                   | <b>0.6 GB/s</b>              | <b>2.0 GB/s</b>              | <b>2.4 GB/s</b>               | <b>4.0 GB/s</b>              | <b>4.8 GB/s</b>                      | <b>8.0 GB/s</b>              | <b>9.6 GB/s</b>                      |

**SAS Supplies 20% More bandwidth  
Per Lane**

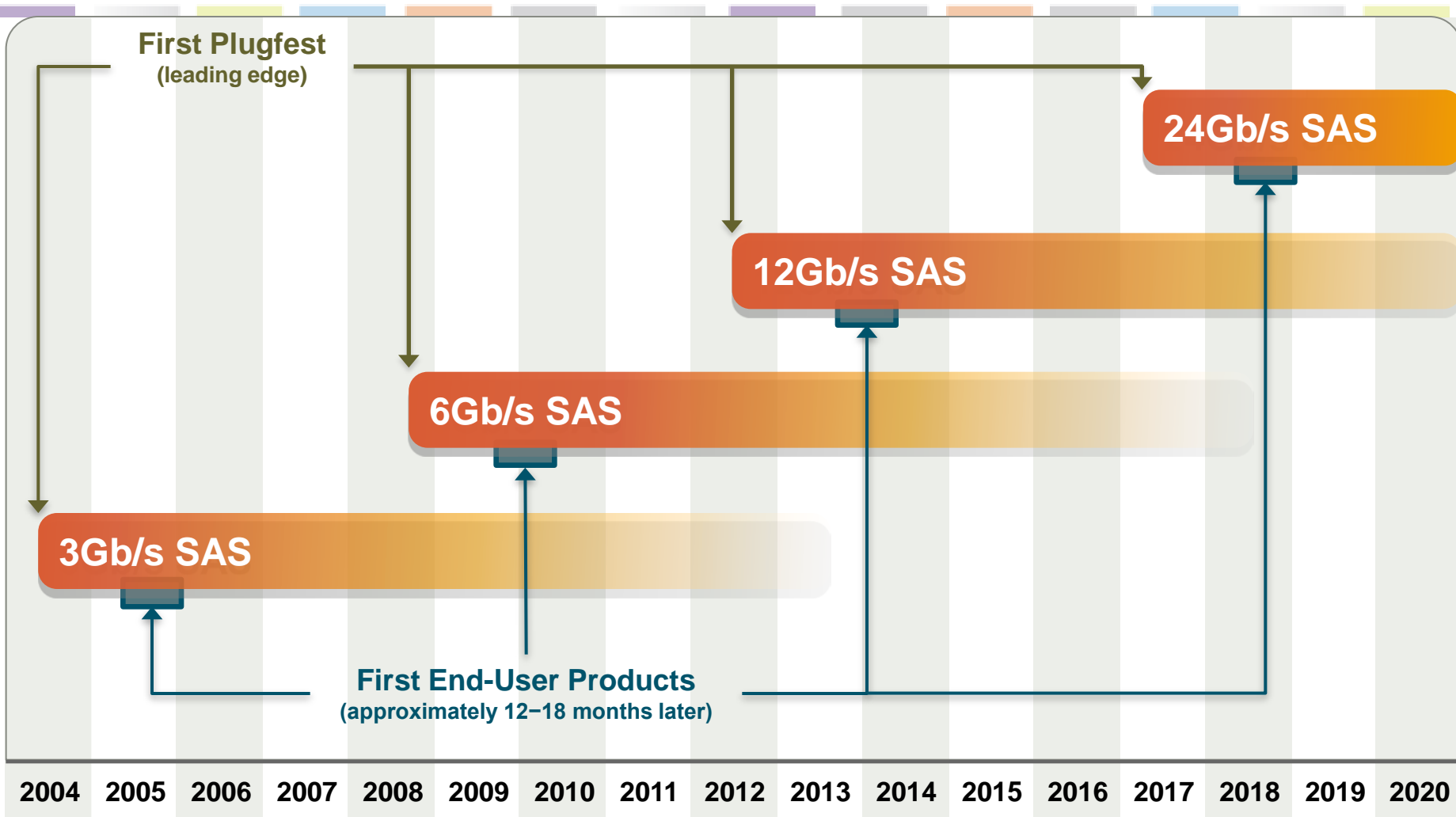
# 4k Random Read Latency

## QD1



**Read Latencies Dominated by NAND Latencies (and will continue to increase)**

# SAS Technology Roadmap



Source: SCSI Trade Association – Aug 2015

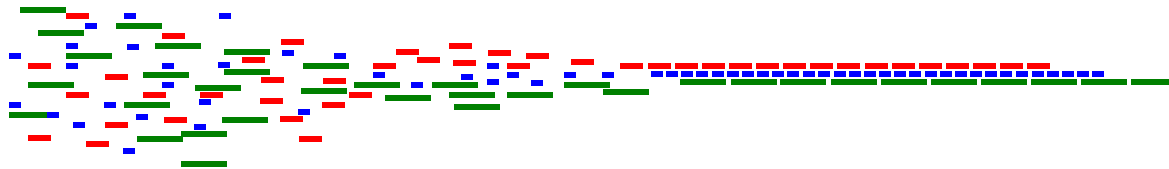
# Recent Innovations in SAS

- Storage Intelligence
- Persistent Connections
- Enhanced Power Control
- Shingled Magnetic Recording Support

**Recent SAS Innovations - the Focus  
of the May SAS Plugfest**

## ➤ Streams

- ◆ Provides hints to SSD about data sets that have similar expected lifetimes
- ◆ Reduces intermixing of data from different applications, thus reducing fragmentation during garbage collection
- ◆ Improves performance
- ◆ Reduces write amplification and improves endurance

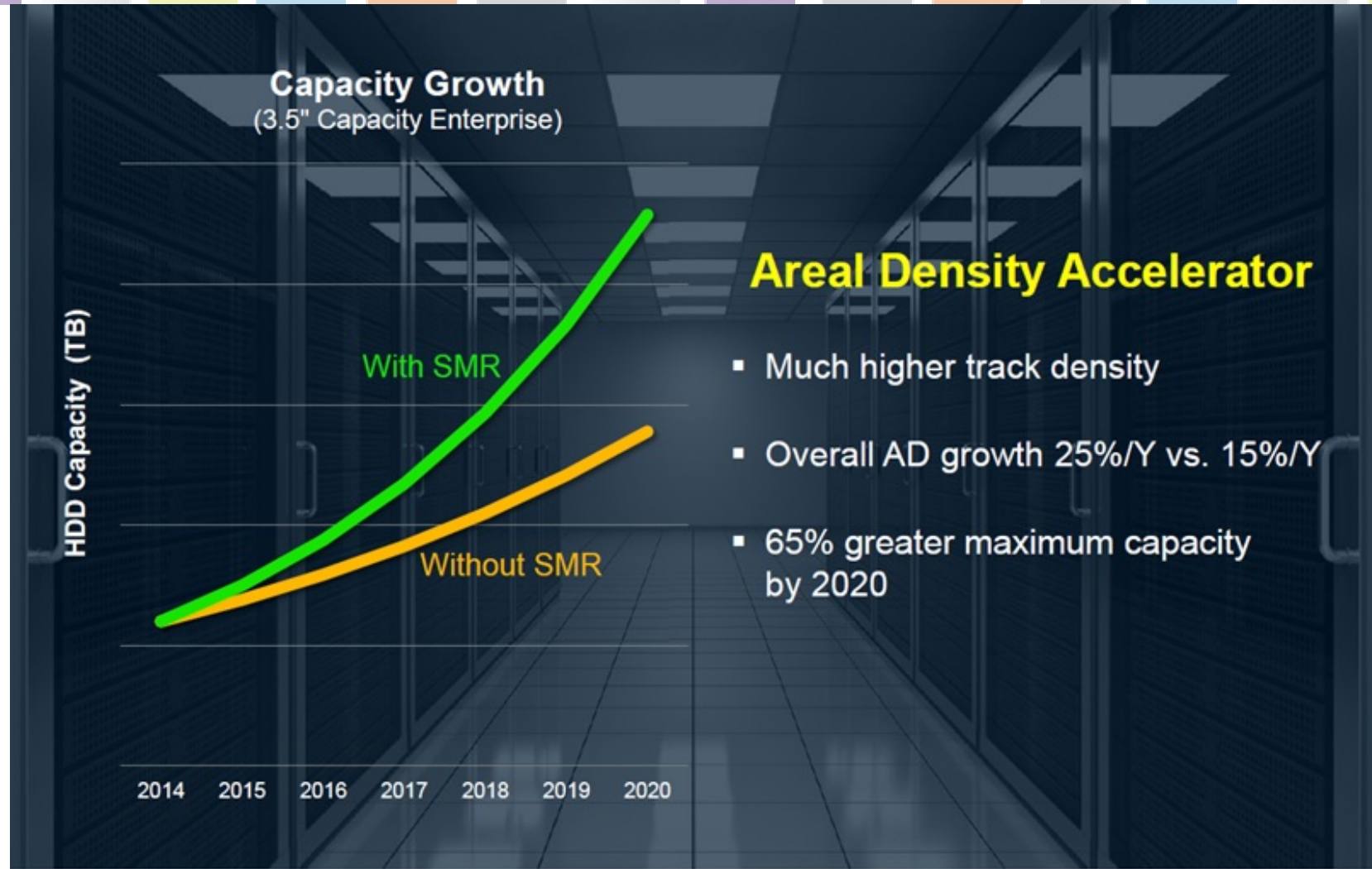


## ➤ Background Activity Control

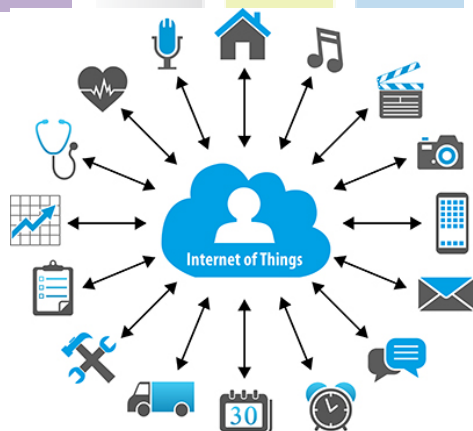
- ◆ Provides hints to SSD to optimize timing of background activities (e.g., garbage collection)
- ◆ Provides more consistent performance during peak activity times



# Why Shingled Magnetic Recording?



# The Need for Speed



**Estimated 50B  
Connected Devices  
in 2020**

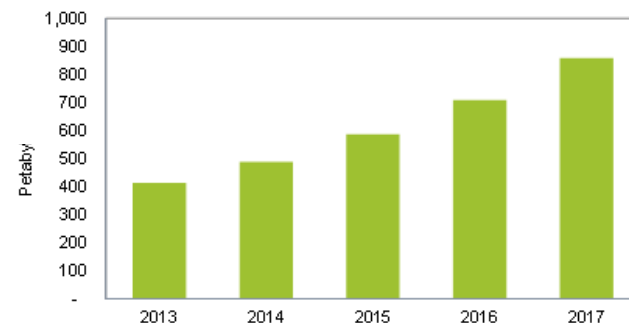


**400 Hours of Video Uploaded  
Per Minute, Nov. 2015**



**DoD Drones Capable of  
Capturing 430 PB/Day**

Global Forecast of Data Generated Daily by Surveillance Cameras Shipped in a Year (in Petabytes)



Source: IHS Inc. October 2013

**Surveillance Cameras Capture  
859 PB/Day in 2017**

# 24Gb/s SAS Objectives

- Double the Effective Bandwidth of 12Gb/s SAS
- Backwards Compatibility
  - ◆ Support for two generations of backward compatibility
  - ◆ Leverage existing ecosystem (tools, test equipment)
- Preserve the Existing SAS Value Proposition
  - ◆ **Reliability** – Robust error handling
  - ◆ **Scalability** – Scalable to 1,000s of devices
  - ◆ **Flexibility** – SAS infrastructure supports SAS and SATA devices
  - ◆ **Serviceability** – Surprise add/remove media and cables
  - ◆ **Manageability** – Storage management built into the standard
- Align with a 2019 Platform Launch



# Summary

- Logical SCSI Lives Across the Storage Spectrum
- Proven Enterprise Attributes and Growing Footprint
- Flexible Architecture = Platform for Innovation
  - ◆ Enterprise reliability, improved connectivity
  - ◆ Low-latency device performance, capacity scaling
- A Multi-generational Investment
  - ◆ Enterprise-hardened middleware
  - ◆ Preserves backward compatibility
  - ◆ Roadmaps preserve legacy investments



# Attribution & Feedback

The SNIA Education Committee thanks the following Individuals for their contributions to this Tutorial.

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